

*Utilization of*  
**NATIVE TIMBER**  
*in farm buildings*

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This is a final report of the results obtained by Homer T. Hurst while on the staff of the Ohio Agricultural Experiment Station 1953-55.

In this abstract, sample graphs have been presented without tables of supporting data. If further information concerning test procedure, test data or results with other wood species is desired, a copy of the full report "Progress Report of the Utilization of Native Timber in Farm Buildings"—by Homer T. Hurst will be furnished upon request. Address requests to Agricultural Engineering Department, Ohio State University, Columbus 10, Ohio.

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# UTILIZATION OF NATIVE TIMBER IN FARM BUILDINGS

WARREN L. ROLLER

## INTRODUCTION

A study of the possible uses of short pieces of native timber in farmstead structures was undertaken by the Agricultural Engineering and Forestry Departments of the Ohio Agricultural Experiment Station in 1953. It was believed that practical methods of using native hardwood would decrease the building and maintenance costs and help bolster the declining state of repair of the majority of farm buildings. Development of new methods of fabrication was believed to be the first step in providing other practical methods of using native timber.

## ANALYSIS OF TRUSS DESIGNS

The fabrication of a truss from hardwood appeared to be a desirable objective. What type of truss to use was the first subject for study. After a study of various types of truss design, it was determined that the Howe and lattice trusses offered the best possibilities for fabrication from hardwood. Thirteen  $\frac{1}{4}$  scale models of the Howe and lattice trusses were built and tested in an apparatus that loaded them uniformly every 6 inches on the model, the equivalent of 2 feet on full scale truss. The lattice design proved to be superior in load carrying capacity, in use of standard size lumber, and in ease of construction from rough hardwood. Thus, the lattice design was adopted as the best possibility for the study.

## COMPRESSION JOINTS

It was anticipated that the study of full size trusses would be next. However, information about fasteners, wood species, and degree of seasoning as they affect the joints of a truss was needed. It was decided to obtain this information independent of the truss construction through a study of compression joints.

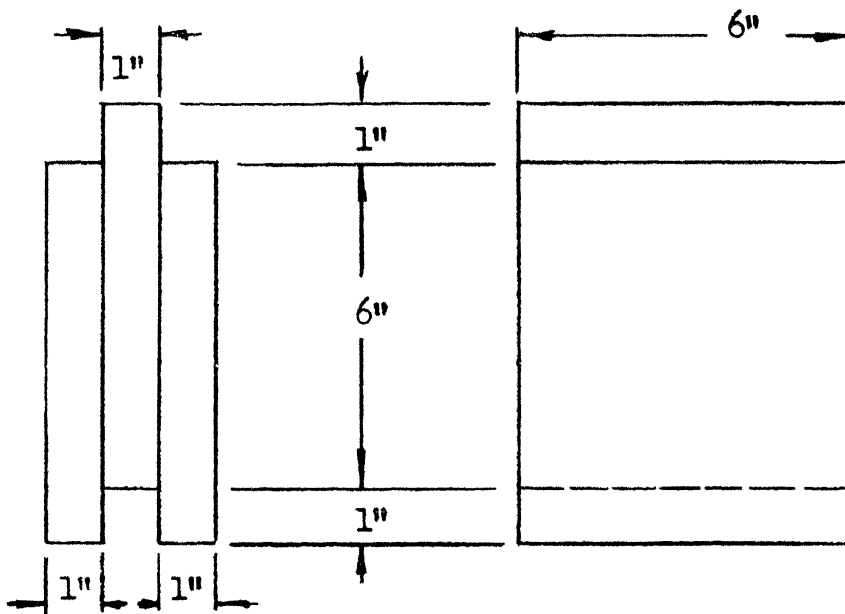


Fig. 1.—Compression joint.

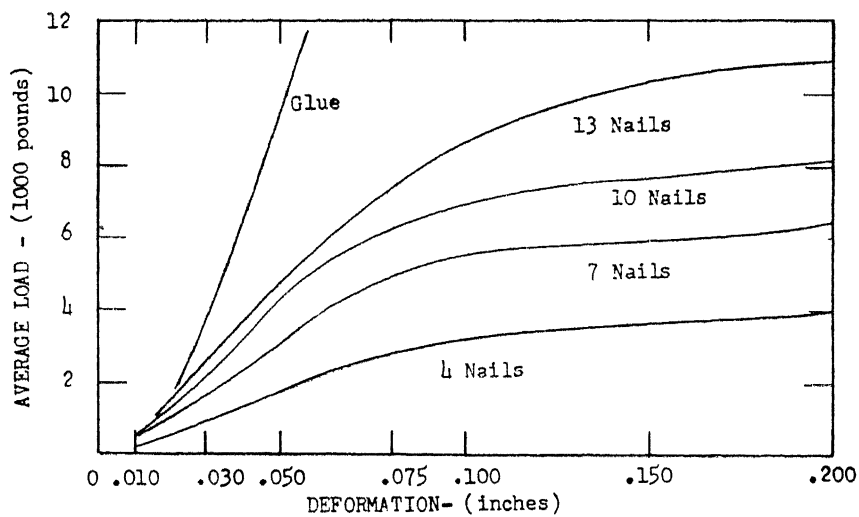


Fig. 2.—Deformation vs. average load (average of three), Screwtite nails, red oak—green.



A total of 248 joints, as shown in Figure 1, were made from rough lumber to test the variables of fastener, species and degree of seasoning. Weldwood glue at the rate of 0.22 pounds per square foot, 16d high-carbon steel Screwtite<sup>1</sup> nails and 16d plain shank common nails were tested. Nails were tested in numbers of 4, 7, 10, and 13 nails/joint. Wood species used were red oak, beech, hard maple, soft maple, red elm, and white elm in both green and air dried conditions. Green samples were tested using both Screwtite and common nails as well as glue. The air-dried samples of each specie were tested using glue and screwtite nails only. Figure 2 is a representative plot of the findings of this series of tests, and illustrates the load-deformation curves for the 15 joints tested using green red oak with Screwtite nails and glue. The machine in which the joints were tested was operated at .052 inches per minute and was stopped briefly at the various loads to read deformations.

Figure 2 shows that it would be very difficult to put enough nails in the joint to approach the load carried by the glued joints at any deformation above about .030 inches.

Figure 3 shows the results of tests of joints from the same green red oak log using seven, 16d common nails compared to seven, 16d Screwtite nails.

<sup>1</sup>Trademark of the Independent Nail and Packing Co., Bridgewater, Connecticut.

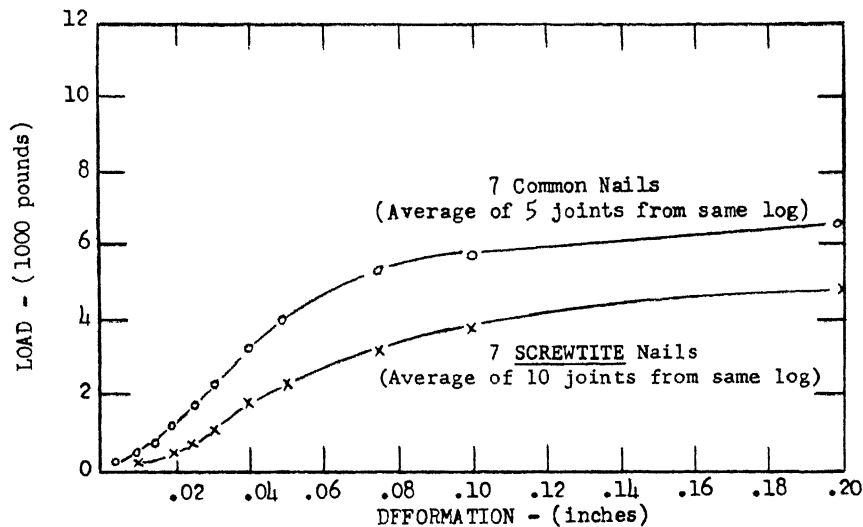


Fig. 3.—Load vs. deformation, red oak—green

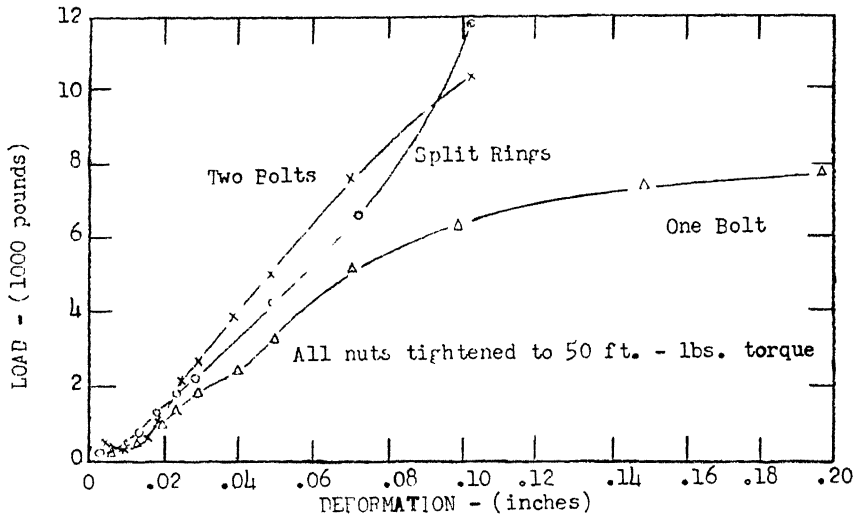


Fig. 4.—Load vs. deformation, red oak—air dry.

It may be seen that common nails had a better resistance to shear between members (resulting in deformation of the joint) than did Screwtite nails.

Thirty joints were constructed of air-dried red oak with bolts and split ring fasteners. Figure 4 shows that for ordinary deflections there is little difference between two bolts and split rings in holding power. One bolt is inferior by a definite margin.

Splitting percentages of the different species by both common and Screwtite nails were kept. The excessive splitting even at an end distance of 12.5 nail diameters suggested that the lattice beam design might be more successfully fastened with nails if soft wood web members were used.

Results of the splitting tests showed that both kinds of nails split the various species of wood at about the same rate as follows:

Red Oak	dry	28.0%	Soft Maple	dry	38.6
	green	17.5		green	14.7
Beech	dry	62.0	Red Elm	dry	42.8
	green	32.3		green	8.1
Hard Maple	dry	----	White Elm	dry	22.2
	green	50.0		green	6.1

Considering .015 inches as a design limit, there is practically no difference in the load carrying capacity of any of the joints, regardless of specie of wood, degree of seasoning, kind or quantity of fastener. However, with deformations of .040 or .050 inches, glued joints are much stronger than any other kind tested. The strength of the nailed joints was not proportional to the number of nails per joint at deformations below .100 inches. Based on these tests it appears that .015 inches is an unrealistically low design limit for farm structures.

There was extreme variability between supposedly duplicate joints in this series of tests of compression joints.

### SIMPLE LATTICE TRUSSES

The study of the lattice truss was undertaken as a continuation of the joint study under loading other than simple compression. These trusses were 32 inches deep with 24 inch panel points and web members running at a  $45^\circ$  angle. Again, the evaluation of the effect of species, degree of seasoning, and fastener was attempted. The trusses were tested as shown in Figure 5.

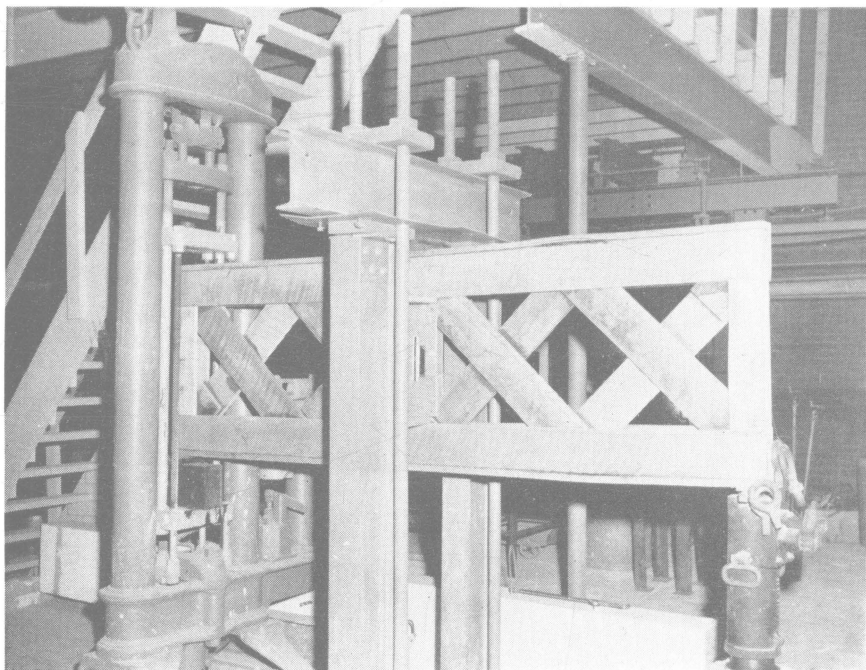


Fig. 5.—Lattice Truss being tested to failure of web members in shear in hydraulic testing machine. Note the separation of the cap from the flange at the midpoint between load and support.

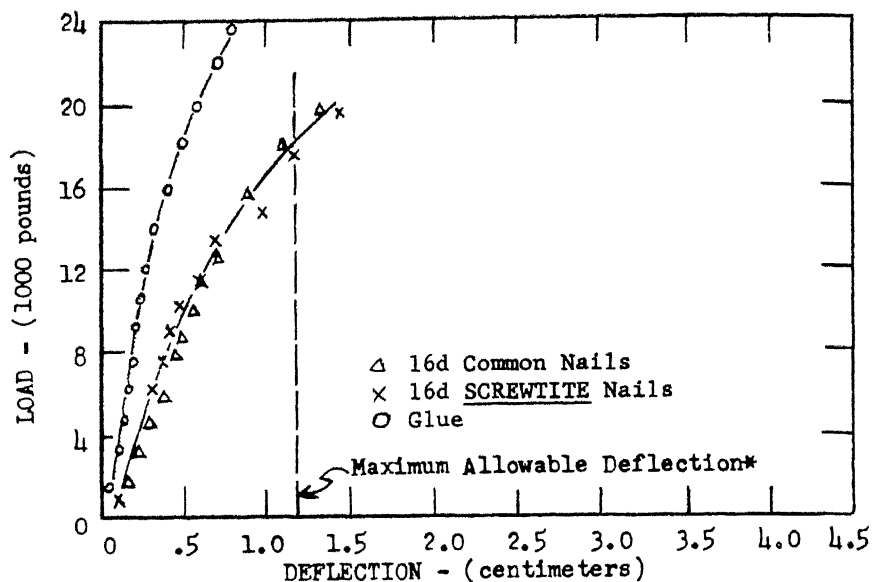


Fig. 6.—Load vs. deflection, 4" × 32"—8' lattice trusses—red oak (built green, tested dry).

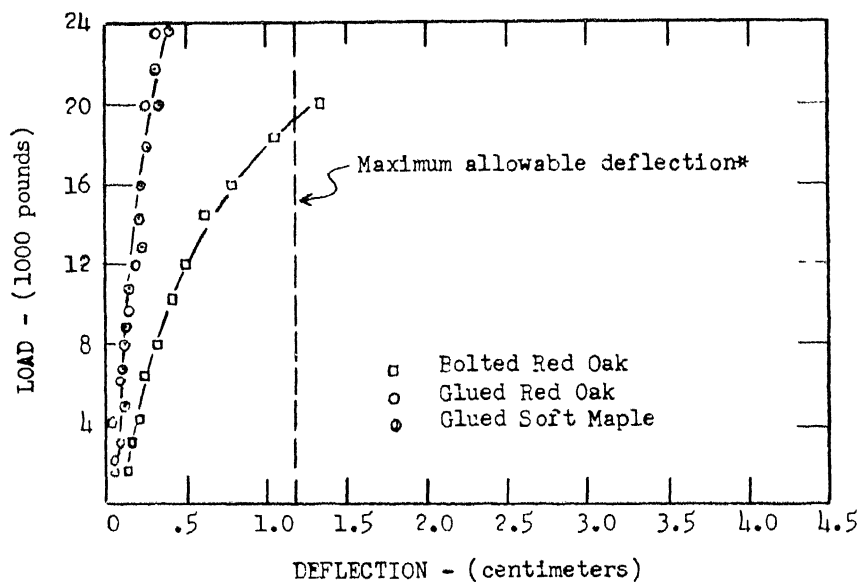


Fig. 7.—Load vs. deflection, 4" × 32"—8' lattice trusses—air dry.

\*Forest Products Laboratory Handbook.

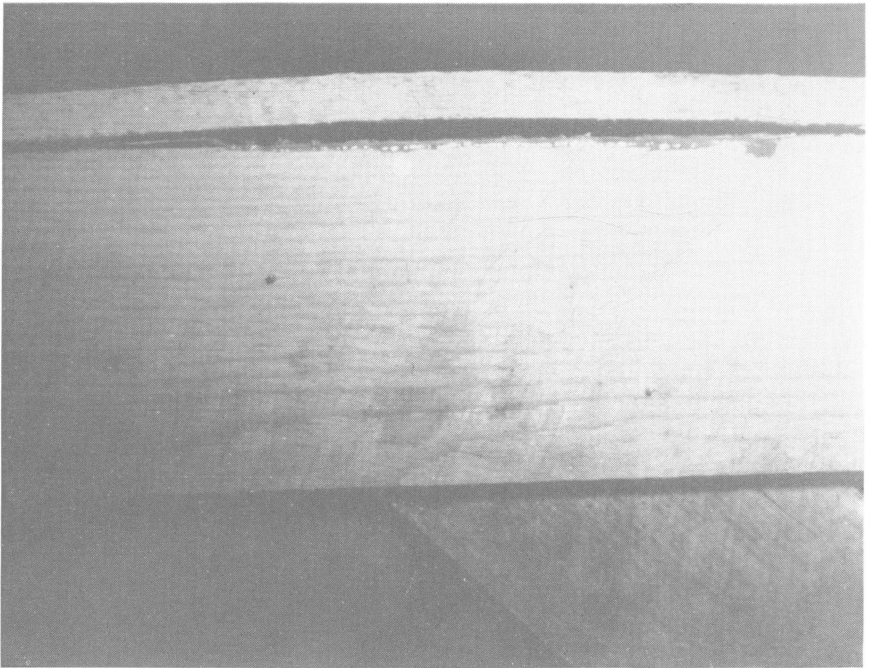
Glued trusses were stronger and stiffer than nailed trusses in most cases. This seemed to be true even though green lumber was used and severe separation of joints occurred during seasoning.

Figures 6 and 7 show some of the results of these tests on red oak trusses.

Figure 6 shows the glued truss to be far superior in load capacity to either of the nailed trusses. Less difference between common nails and Screwtite nails occurred in this test than in the test of compression joints.

Figure 7 shows the great superiority of glue over bolts.

The ultimate load and points of failure were recorded in most cases; but, those failures refer to actual rupture of the wood. The real failures of the trusses usually occurred in the top or bottom joints midway between the load and support at less than ultimate loading. Shear failure between web members nearly always occurred first. After shear failure occurred between web members the member in compression pushed the top cap away from the flange. See Figure 8.



**Fig. 8.—Cap separated from the flange due to failure of the web member in compression.**

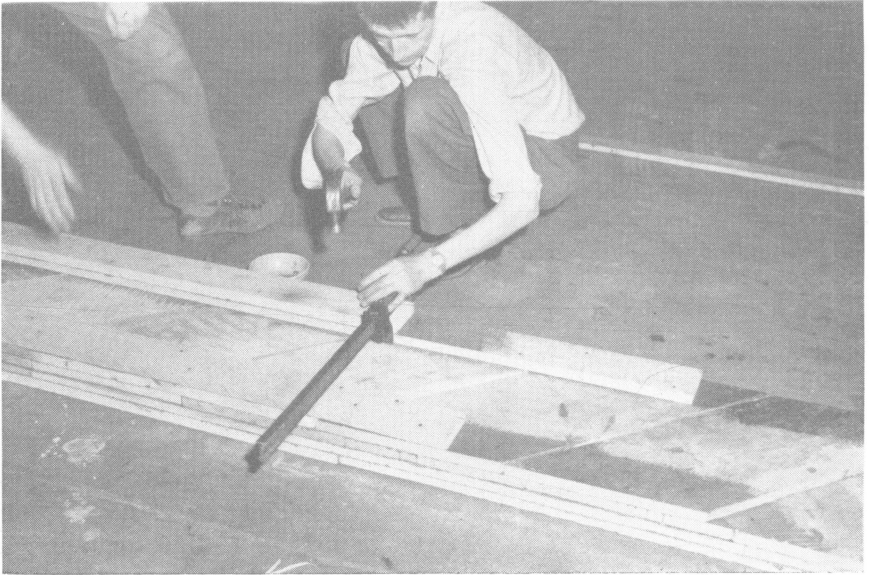


Fig. 9.—Fabrication of lattice beams with rough hardwood using student labor.

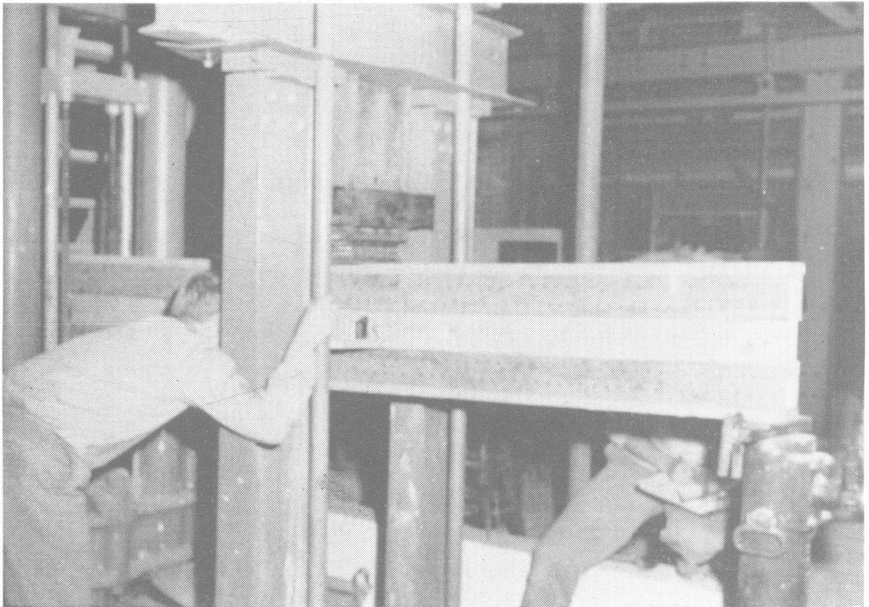


Fig. 10.—Testing of an 8-foot lattice beam on an hydraulic testing machine.

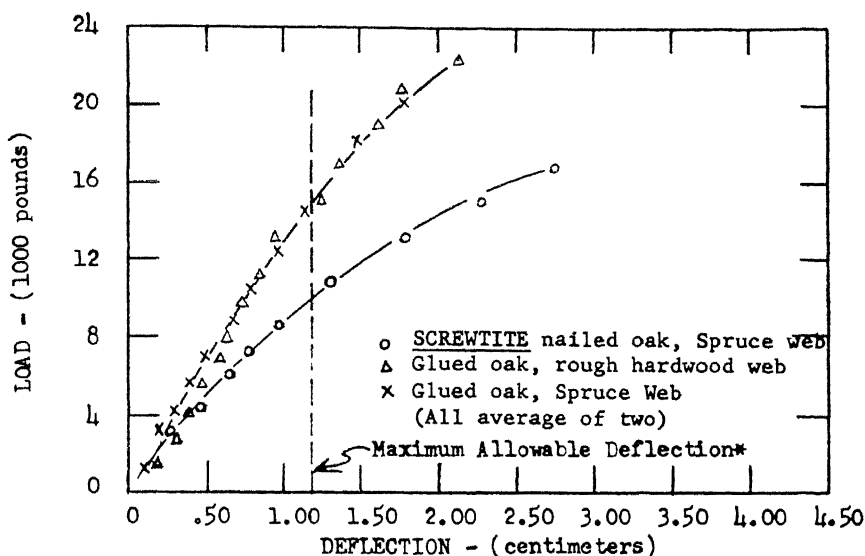


Fig. 11.—Load vs. deflection, 4" × 14"—8' lattice beams, air dry lumber.

After testing, the bolts were removed from the green soft maple trusses for examination. The bolts showing the greatest deformation were taken from the two bottom joints mid-way between load and supports. The next two most severely deformed bolts came from the top joints mid-way between load and support. The other bolts removed were not visibly deformed.

In the tests of the lattice trusses the fact that more variation occurred within treatments than between treatments in many cases was quite troublesome. This again illustrates the great difficulty in designing and building with wood because of its lack of homogeneity.

### SIMPLE LATTICE BEAMS

The study of lattice beams was anticipated as the second step in the investigation. However, the problem of fasteners fostered the compression joint study. As a result of this joint study the lattice beams were constructed to compare nailed beams with solid soft wood webbing to glued beams with solid hard wood webbing.

These beams were fabricated as shown in Figure 9. Beams were 14" deep with 4" wide flanges and 2" thick webbing. An 8' lattice beam is shown under test in Figure 10.

Figure 11 shows the comparison of glue and nails for fabrication of beams. As expected, the deflection was much greater in the nailed beams than in the glued ones and the ultimate load smaller. The outer fibers of the caps should have been deformed more by a given load than the outer fibers of the flanges. Since this was not true, it indicated that the caps were inadequately fastened to the flange. Nearly all beams failed at the center, usually in the lower flange.

Although this part of the study was not completed, enough information was obtained to support the belief that the fabrication of beams in this manner with short pieces of hardwood for caps and flanges and softwood for webbing offered good promise as a means of using native timber in farm structures.

Strain Gauge readings were taken using a 20-inch Berry Strain Gauge.



**Fig. 12.—Construction of a solid web continuous lattice beam in the laboratory.**



## TWO-SPAN CONTINUOUS LATTICE BEAMS

The two-span continuous lattice beam was the expected final product of the study. Such a beam offers the possibility of constructing buildings with wide, clear spans with no posts or supports, yet made from short pieces of native hardwoods.

Figure 12 shows the construction of one of these continuous beams. Beams were built  $6'' \times 18'' \times 32'$  of air dry lumber for the tests. Figure 13 shows one of the beams under test. Some of the results of the tests on these beams are shown in Figure 14. In this case it appears that the glued oak was only slightly better than the bolted oak. This is probably misleading due to the absence of a reading at higher loads on the glued oak.

One of the objectives of this series of tests was to find a satisfactory method of splicing these beams. The idea of splicing at the contraflexure points of the beam was tested. The beams were tested, then cut at the contraflexure points and spliced as shown in Figure 15.

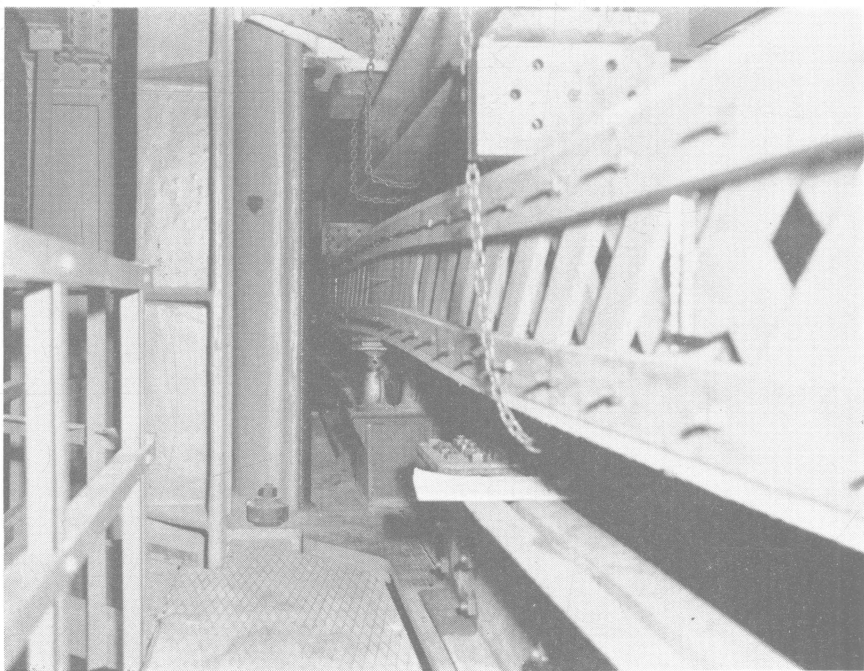


Fig. 13.—One of the continuous lattice beams being tested in the Engineering Experiment Station Laboratory.

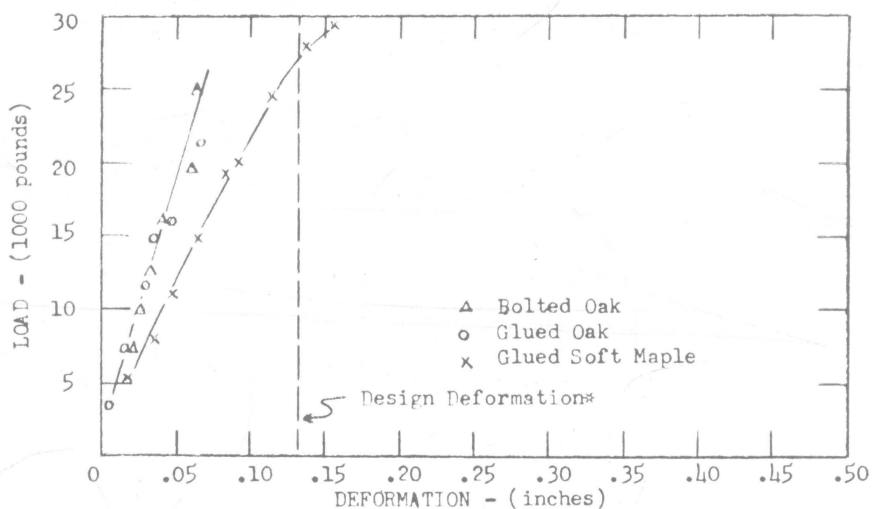


Fig. 14.—Load vs. deformation, tension in edge of top cap at center, 6" × 18"—32' lattice beams, air dry lumber.

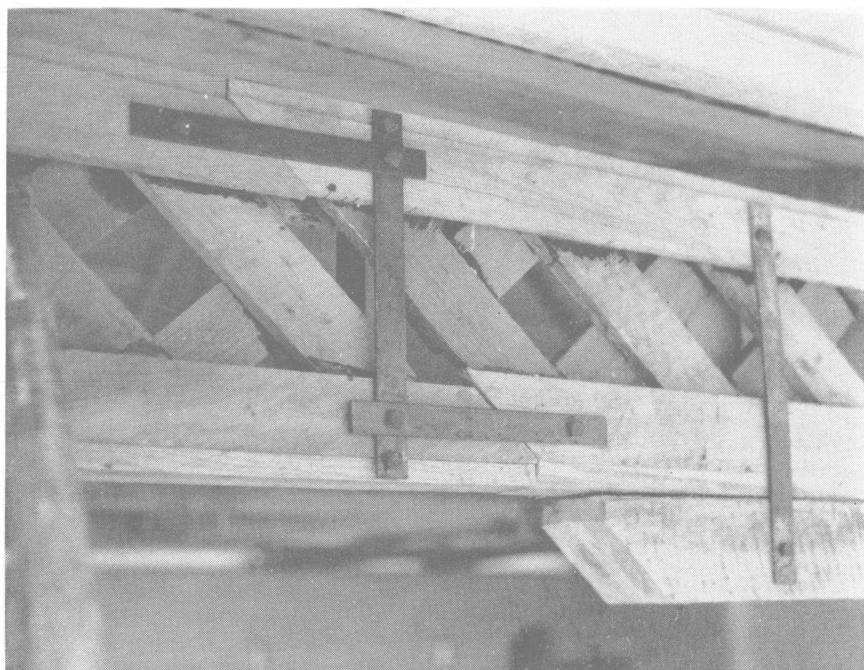


Fig. 15.—Method of splicing continuous lattice beams at contraflexure points with bolts and steel straps.

The load-deflection curves before and after splicing are shown in Figure 16. It can be seen that the severing and rejoining at the point where longitudinal stress is low and where transverse stress is smallest (at  $\frac{1}{4}$  and  $\frac{3}{4}$  distance between supports) results in very little loss of strength. Thus it becomes possible to fabricate these beams in sections and splice them on the building site. Also it may be seen again that glue adds much to the strength and stiffness of beams built of rough hardwood compared to the use of bolts. However, bolts as well as nails made beams stiff enough that design stress limits were exceeded before maximum allowable deflections were reached.

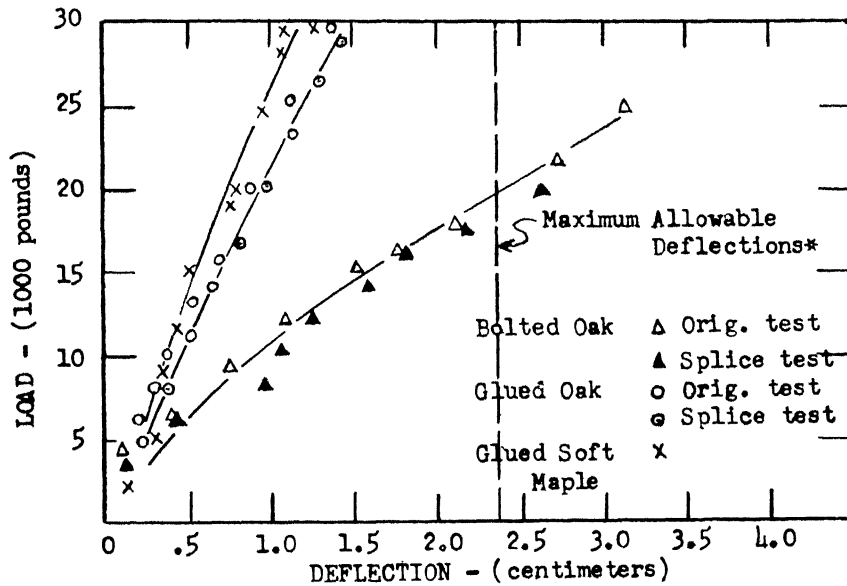


Fig. 16.—Load vs. deflection, 6'' × 18''—32' lattice beams, air dry lumber.

### MACHINERY SHED

In order to field test the results of this study, a 30' × 126' concrete block machine shed was built on one of the Experiment Station farms. Glued, nailed, and bolted trusses of various species of rough hardwood were used as roof supports. Some trusses of sized Douglas Fir were also

used for comparison. The glue used on all glued roof trusses was Phenol Resorcinol Resin glue. The front ends of the roof trusses were supported on the continuous lattice beams. Two continuous lattice beams, one covering three 24' spans and the other covering three 18' spans were built of air dry red oak with bolts and glue as fasteners. Both beams are 18" deep. The one covering 24' spans is 6" wide and the one covering 18' spans is 4" wide. Each beam is composed of two test sections, one fastened with bolts and the other with glue, and a non-test center section which fills the space between the two contraflexure points of the center span. The beams are spliced at the contraflexure points of the two center spans with steel straps, bolts, and lag screws.

Construction of the roof trusses and erection of the shed are shown in Figures 17 and 18. Figure 19 shows the completed machinery shed.

Students built the glued 4" and 6" width beams at the rate of .31 and .42 man hours per foot of length. The bolted beams required 36 percent more labor per foot of length than glued beams.



**Fig. 17.—Construction of the experimental trusses for the roof supports in the machine shed.**

The machine shed will be inspected annually and a record kept of the general conditions of the various trusses and beams. Deflection will be taken of all beams and trusses at the time of the annual inspection and also anytime throughout the year when the building is subjected to unusual snow or wind loadings.

## CONCLUSIONS

The following conclusions are suggested by the results of this study:

1. The lattice beam constructed of rough sawed native hardwood appears to be a satisfactory method of utilizing short pieces of native timber in the construction of farm buildings.
2. Glue appears to be considerably superior to any of the conventional fasteners or timber connectors for the fabrication of these hardwood beams and trusses. However, bolts and nails both made the beams stiff enough that the maximum design stress was reached before the maximum allowable deflection.

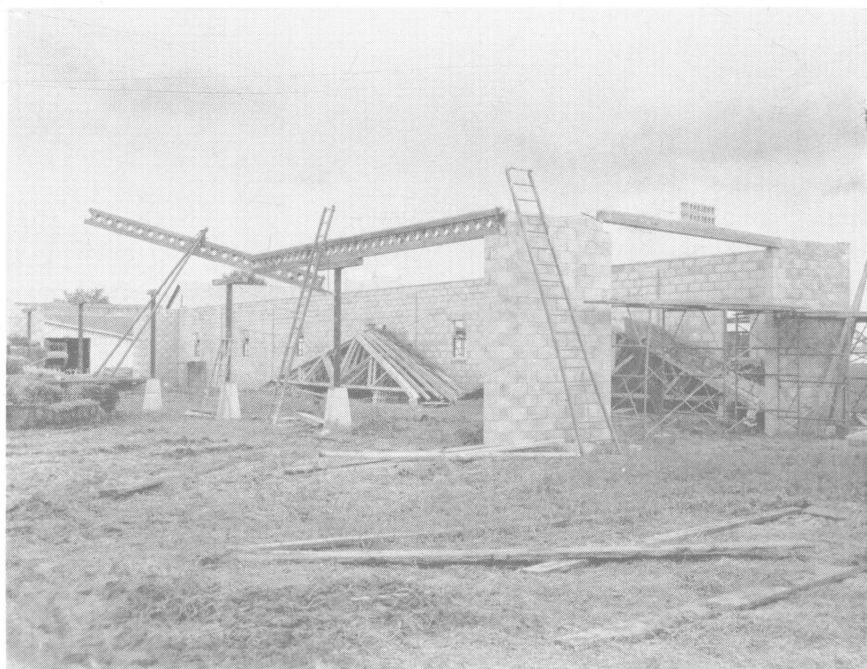


Fig. 18.—Erection of the experimental beams and roof trusses was accomplished by students and farm carpenters.

3. The method used in making multi-span, continuous, lattice beams seems to be practicable. Continuous annual inspections of the experimental machine shed will show how successful these beams and trusses will be in service.



**Fig. 19.—The completed machine shed without roof supporting obstructions.**